Display and Analysis of AVIRIS Data on Personal Computers

W.T. Jansen
WTJ Software Services
San Mateo, California

C. D. Elvidge and Zhikang Chen
Desert Research Institute
University of Nevada System
Reno, Nevada

ABSTRACT

A software system for the display and analysis of AVIRIS data has been developed for 386 and 486 computers equipped with super VGA graphics. The software has functions for simultaneous display of 1) three band color composite imagery, 2) 5X magnification of color imagery, 3) image cube cross section, and 4) full spectrum from any pixel or any group of pixels. Other functions permit the extraction of pixel digital number (DN) values, application of gains and offsets (e.g. conversion to ground reflectance), and spectral matching using spectral libraries. Additional functions are currently being implemented to meet the requirements of AVIRIS researchers.

I. INTRODUCTION

Images of the planet Earth acquired from space give both a regional and global perspective to scientists studying static features and dynamic processes on the surface of the globe. Since the early 1960s, various satellites have been transmitting images of the earth. The Landsat Thematic Mapper (TM), Multispectral Scanner (MSS), SPOT, and other satellites measure radiance values at several points on the electro-magnetic spectrum. Color images can be reconstructed from the data transmitted.

Though spatially limited, data from airborne imaging spectrometers show much more detail in measured spectra than current satellite data gathering instruments. There are more data channels (i.e., 64 for GERIS and 224 for AVIRIS), and each of the channels covers a narrower spectral range resulting in a more precise definition of absorption and emission features in the spectrum gathered. Patterns of absorption features assist the identification, rather than the mere discrimination, of earth surface materials.

In the past, when only a few channels of data were available, it was useful to display individual channels as individual colors (i.e., Red, Green, Blue) on a monitor allowing the observer to estimate the relationships between the data channels as defined by the hue, intensity, and saturation of the pixels in the resulting image. To use more of the measured data channels in the final display, each of the primary RGB colors could be a function of two or more channels (i.e., a ratio, product, difference, or some other function). Existing image processing methods emphasize the variation of colors in the resulting image to simplify the interpretation which by this time has become more of an art than a science. This method of data analysis is impractical for imaging spectrometry as the large number of channels overwhelms the ability of the RGB display to show visually discernible differences.

We experienced the need to go beyond the display of images generated by a few selected channels, and wanted to show and compare complete spectra from pixels in the same (or any other) image and the spectra from a large reference library. In our system, cross-comparisons between image and library spectra are made to identify pixel composition and mineral distribution. A variety of functions are available to allow detailed study of spatial and spectral relationships in the data in real time.

II. SYSTEM FUNCTIONALITY

The system can be broken down into six primary features (see Figure 1).

A. Data Import and Pre-processing

Data from the AVIRIS scanner and others is typically distributed on 9-track CCT magnetic tapes.We import this data by copying the files directly from the tape to a hard disk. A program merges the calibration information from the tape and data measured in the field, and then implements several coefficients to convert the scanned digital numbers to emissivity spectra.

B. Library Creation

The steps taken to develop the standard spectral library consisted of the following:

1. Collect and prepare mineral and vegetational standards
2. Measure standard spectral at high resolution
3. Create and manage high resolution spectral library
4. Resample library to scanner resolution.

Steps 1-3 have been executed by the staff at CSIRO, Sydney, Australia, resulting in a library containing over 200 mineral spectra. At present time, a vegetation library is being created. Other spectral libraries will be included as they become available.

A program has been developed to resample the high resolution library to the resolution of the most commonly used airborne and satellite scanners. The spectral positions of both incoming and outgoing channel windows can be tracked. Custom definition of a series of spectral windows allows the user to re-define the scanner characteristics as field instruments are re-calibrated.

C. Image Loading

Imagery prepared in section A above is loaded for display by this program.The user selects up to three bands from the spectral image file and a contrast stretch to create a composite RGB image for the display screen. Alternatively, by loading a co-registered, user created image and then linking it to the original spectral data file, the validity of user-defined pre-processing techniques can be examined. If images are larger than 512x512 pixels, either the entire image subsampled to that size, or a full resolution sub-image can be shown. Images are loaded into high resolution VGA.

D. Screen Display

Figure 2 shows the flow diagram for the core program in the software system. After an image has been loaded, the user interface screen layout appears as shown in Figure 3. (A sample screen is shown in Figure 4). The user interface screen has seven distinct components:

1. Image area

Displays the image to be interpreted and a freely roaming cursor under mouse control that quickly points to any pixel. Spectral classification maps are also displayed here. Toggles between maps and loaded RGB images.

2. Spectral graph

Typically shows up to three spectra: 1) the spectrum for the pixel identified by the image cursor, 2) the contents of a temporary spectral memory, and 3) an averaged spectrum from several user-defined pixels. Also shows up to three vertical RGB cursors. The RGB cursors initially indicate which channels were used to display the image. Subsequently, they can be moved to identify spectral features and to modify the contents of the zoom window, the scanline display, and the image area.

3. Zoom window

Magnifies a portion of the image centered on the image cursor so individual pixels can be identified easily. It can be switched to show an enlarged, more highly resolved version of the scanline display window or scatter diagrams for any channel pairs.

4. Scanline display window

Represents a spatial-spectral cross section of all the spectra along the image scanline on which the image cursor is currently located. It can also be switched to show the relative intensity values along that same scanline for the channels currently identified by the RGB cursors and the computed relative spectral differences.

5. Information line

Displays information relating to: 1) image cursor position and size, 2) the RGB cursors' wavelength, intensity, and channel values, 3) the user selectable wavelength range of the spectral graph, and 4) relative spectral similarity values between the displayed spectra. When the library function is invoked, it also indicates the name of the mineral or other specimen whose spectrum is being shown.

6. Color ramp

The colors in the ramp are modified along with the rest of the screen as the various functions in the color modification menu are exercised (brightness, contrast, saturation, etc.).

7. Menu

Indicates the currently available functional choices from the multiple-level hierarchically structured menu system.

E. Analytical Tools

The tools listed below are those we felt were of most immediate need to the hyperspectral analyst. The open architecture of the software will accommodate expanded and new functionality.

1. Spectral comparisons

Spectra can be saved on screen for immediate comparisons with other spectra on the same image. Image spectra can also be compared with reference library or imported spectra.

2. Spectral averaging

Averaged spectra, from variably sized rectangles or randomly selected pixels, can be displayed and saved on the disk in ASCII format for subsequent processing or plotting. They can also be recalled so that direct, on-screen spectral comparisons can be made with data from other images.

3. Spectral channel profiles

Up to three channel profiles along a scanline can be displayed to show the relative channel values and hence the existence and location of spectral absorption features.

4. Spectral stacking

Stacking of a series of spectra from adjacent pixels allows tracking of spectral features as a function of position in the image. A spatial-spectral surface is shown emulating a 3-D terrain diagram. Through color coding and density slicing, spectral digital number (DN) contours are readily observed.

5. Image data cube cross section

Represents a spatial-spectral cross-section of all the spectra along the image scanline on which the image cursor is currently located. Density slicing brings out the spatial relationship of spectral features.

6. Color stretching

Performs visual display enhancement to bring out features in the data. This includes all standard color stretching techniques such as contrast and brightness control, histogram, and gaussian equalization, color inversion, and density slicing. These are all performed in real-time under mouse control, with the changes recorded both graphically and numerically. The effects of the changes are shown instantaneously throughout the screen, including the color ramp. Furthermore, the system is capable of real-time stretching in the IHS domain.

7. Pan and zoom

Rapid access to the spectral information at any pixel is provided by moving the image cursor. The zoom window is instantaneously updated as image or spectral cursors are moved. The spectral cursors are used to identify wavelength, digital number (DN), and channel number.

F. Import and Export of Spectral and Image Data

1. Spectral import and export

At almost all levels of the core program, it is possible by a single key stroke to import and export spectra. Spectra extracted from the image or library are saved in a "spectral register" that allows one to average and compare spectra. The resulting averaged spectrum may be saved to a disk file in ASCII format for plotting or further examination. The output file also contains the coordinates of the spectral source pixels. Similarly, data from such an ASCII file can be loaded into the spectral register for comparisons to spectra in the currently displayed image.

2. Image import and export

The user can make a hard copy of an image modified by color stretching or other image processing functions by saving it to a disk file. The entire screen or just the image portion can be saved. An example of a saved screen displaying an AVIRIS image is shown in Figure 4. Saved spectral classification images can be combined to create mineral distribution maps. The RGB cursors can be used to select the channels when importing an alternative image.

III. CONCLUSION

The emphasis of this system is to analyze spectra and to extend such analysis to the spatial domain. Displaying both images and complete spectra simultaneously, the system is optimized for use with remotely sensed data having large numbers of spectral bands. Some image processing functions have been omitted as they are readily available from other sources. By creating the ability to load the results of external image processing in conjunction with spectral image data cubes, we provide the best of both worlds. The user can experiment with various surface characterization techniques and check the results against the original spectral information.

We have created a set of PC-based tools that present and interpret spectral data from satellites and airborne imaging spectrometers. As a diagnostic tool for identifying the biological and mineralogical composition of the earth's surface, the system addresses the special needs of scientists using data from a variety of imaging spectrometers. The system helps relate variations in image pixel spectra to physically meaningful, spectral reflectance knowledge bases.

REFERENCES

Fred Kruse, et al., Photogrammetric Engineering & Remote Sensing, January, 1990, pp. 83-92.
Jon Huntington and A. A. Green, Bicentennial Gold, Melbourne, May, 1988, pp. 246-258.

ACKNOWLEDGEMENTS

We would like to thank the following individuals for their encouragement, support, and valued assistance with the development of the system: Russ Cowart, Jon Huntington, and Fred Kruse.

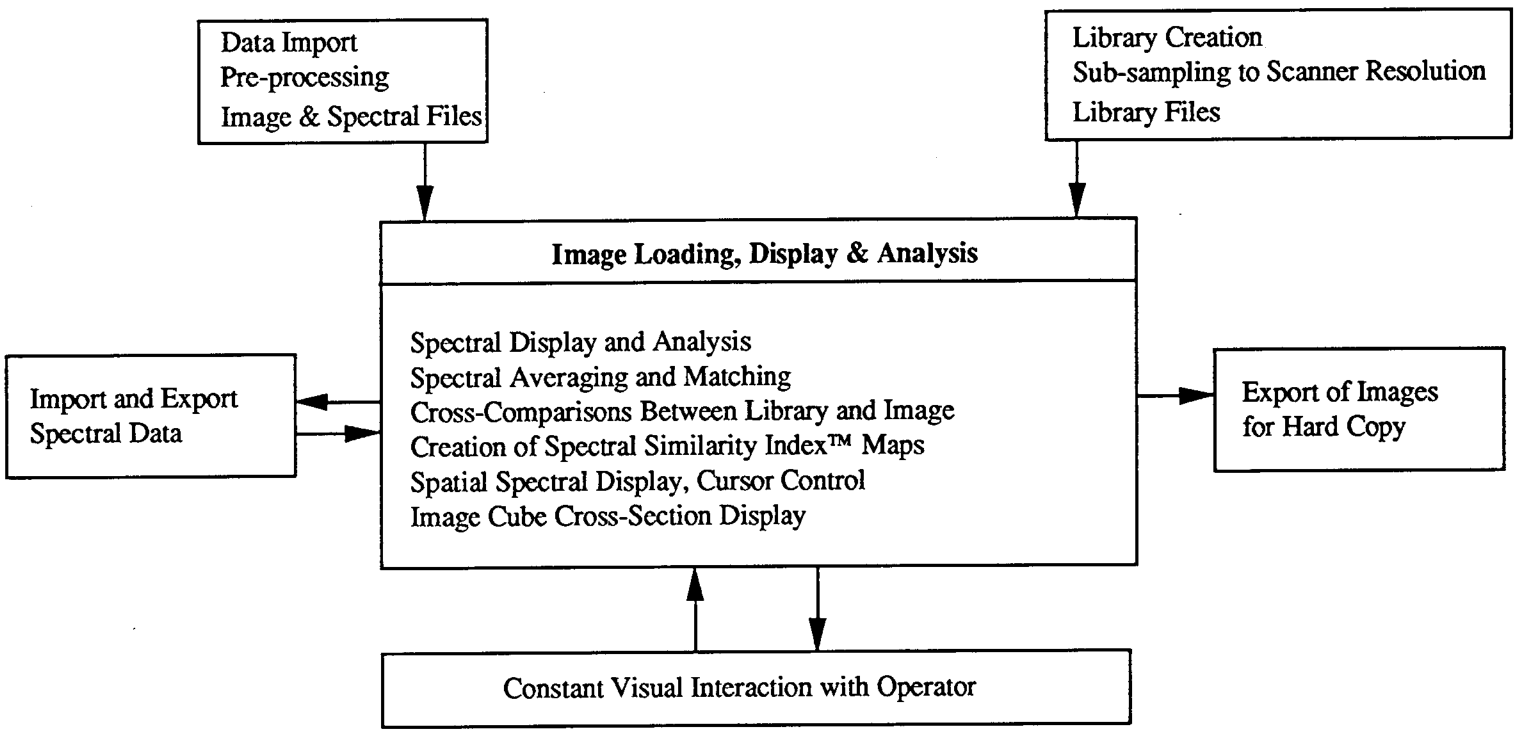

Figure 1: System Functionality

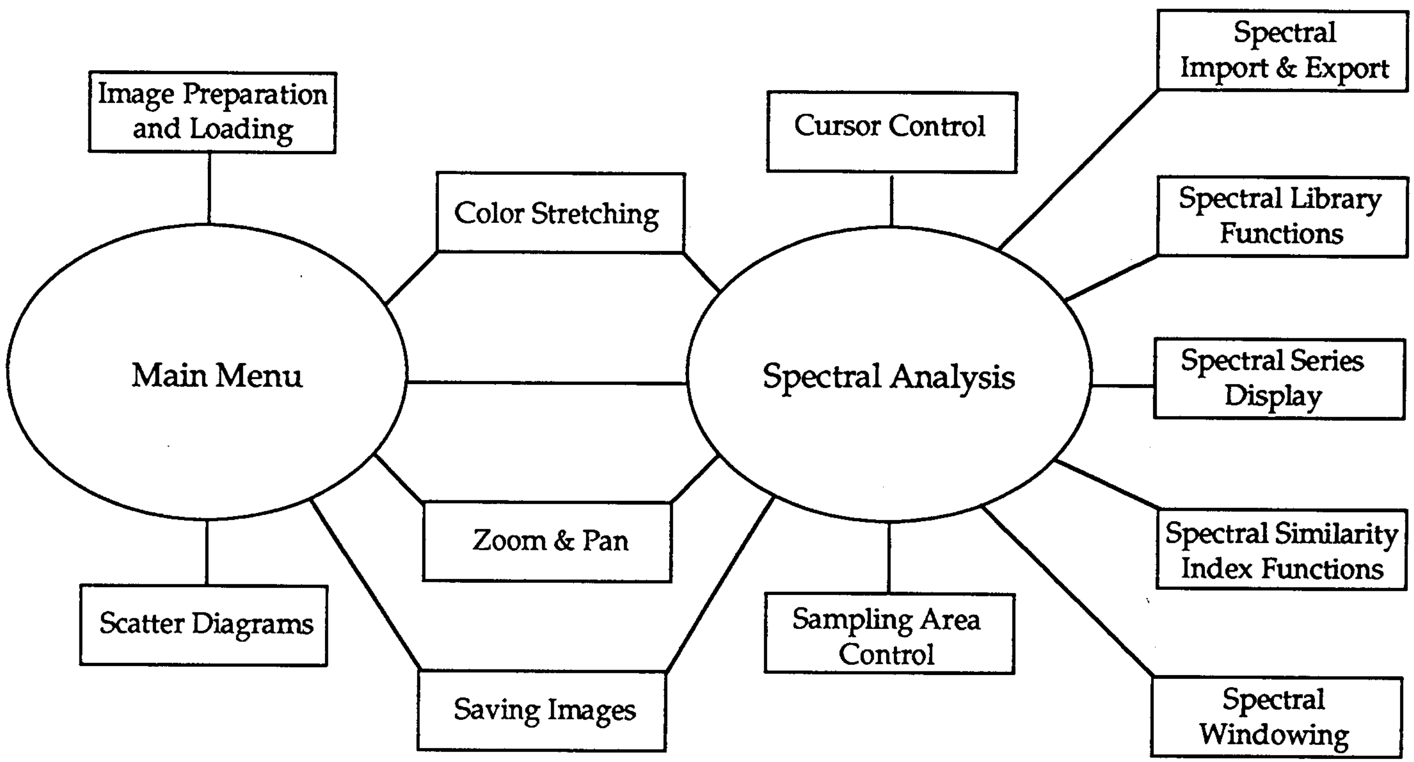

Figure 2: Core Program Flow Diagram

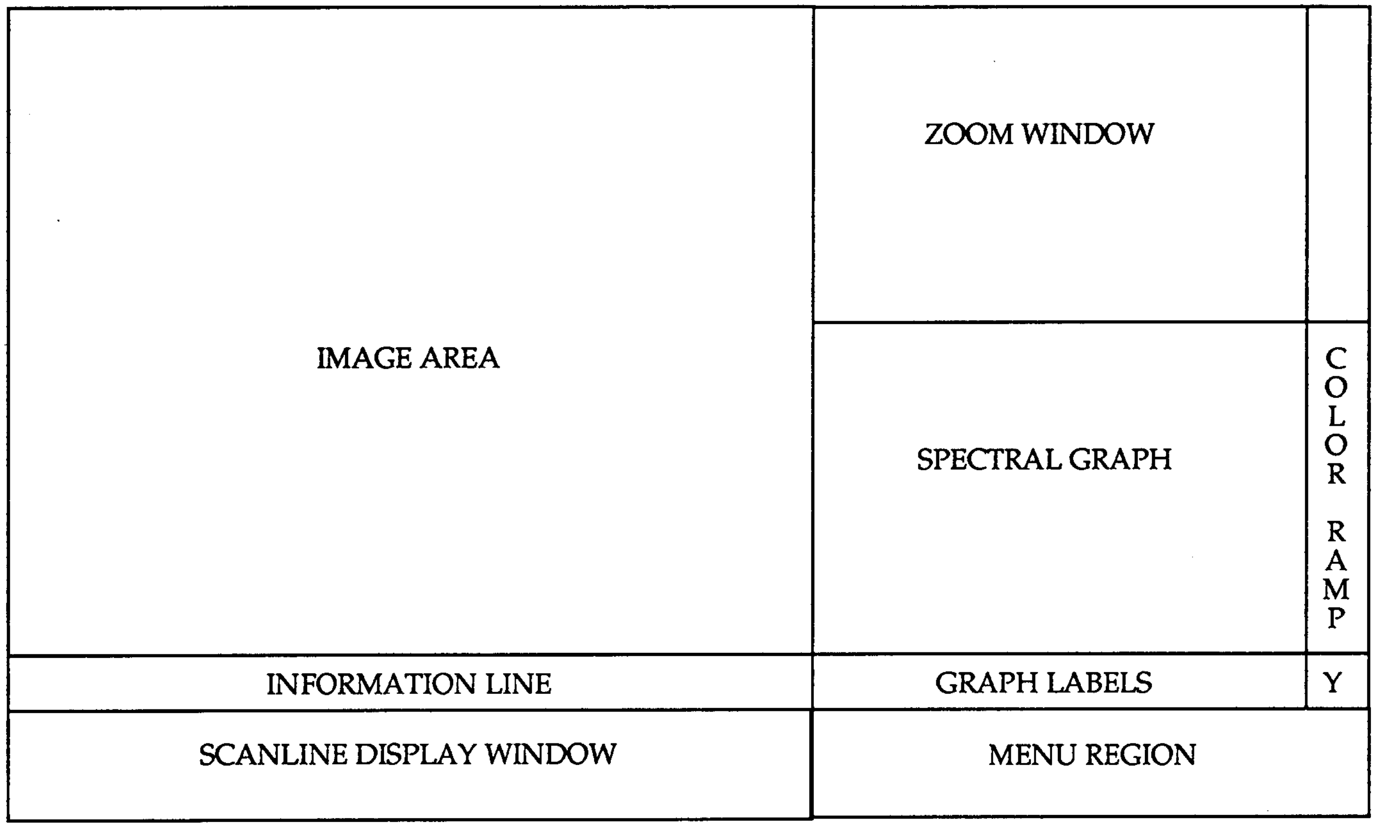

Figure 3: User Interface Screen

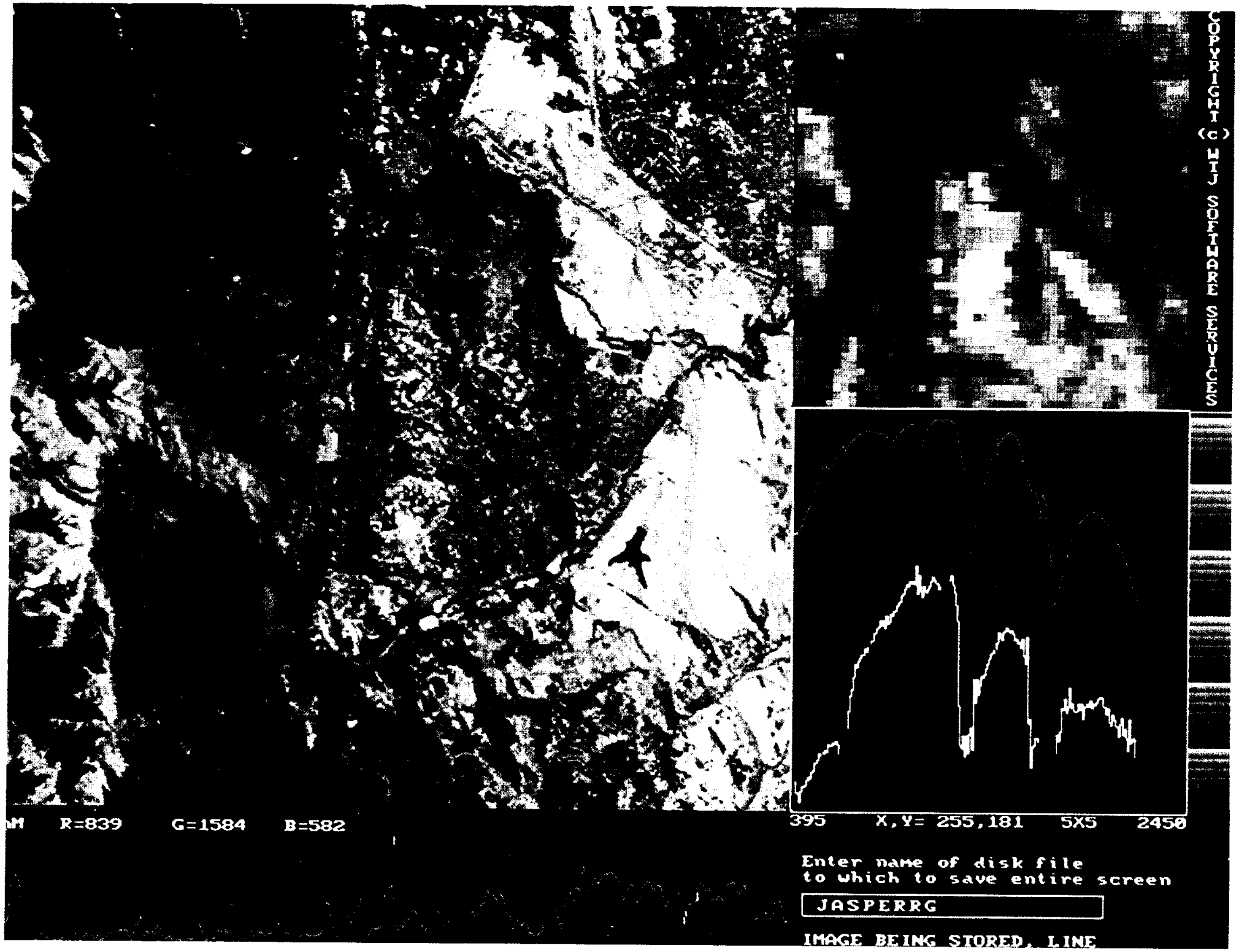

Figure 4: Saved Screen Displaying AVIRIS Image and Spectra [see slide 10]